

# Package ‘bfbin2arm’

February 24, 2026

**Type** Package

**Title** Bayesian Bayes Factor Design for Two-Arm Binomial Trials

**Version** 0.1.0

**Description** Design and analysis of two-arm binomial clinical (phase II) trials using Bayes factors. Implements Bayes factors for point-null and directional hypotheses, predictive densities under different hypotheses, and power and sample size calibration with optional frequentist type-I error and power.

**Depends** R ( $\geq 4.0.0$ )

**Imports** stats, VGAM, ggplot2, dplyr, patchwork

**Suggests** knitr, rmarkdown

**License** GPL-3

**Encoding** UTF-8

**RoxygenNote** 7.3.3

**VignetteBuilder** knitr

**NeedsCompilation** no

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**Repository** CRAN

**Date/Publication** 2026-02-24 19:20:02 UTC

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BFminus0	<i>Bayes factor BF-0: H- vs H0</i>
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### Description

Bayes factor BF-0: H- vs H0

### Usage

BFminus0(BFminus1, BF01)

### Arguments

BFminus1	Value of $BF_{-1}$ .
BF01	Value of $BF_{01}$ .

### Value

Numeric scalar,  $BF_{-0}$ .

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BFminus1	<i>Bayes factor BF-1: H- vs H1</i>
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### Description

Bayes factor BF-1: H- vs H1

### Usage

BFminus1(y1, y2, n1, n2, a\_1\_d = 1, b\_1\_d = 1, a\_2\_d = 1, b\_2\_d = 1)

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_1_d, b_1_d	Design-prior shape parameters for $p_1$ .
a_2_d, b_2_d	Design-prior shape parameters for $p_2$ .

**Value**

Numeric scalar,  $BF_{-1}$ .

---

BFplus0                      *Bayes factor BF+0: H+ vs H0*

---

**Description**

Bayes factor BF+0: H+ vs H0

**Usage**

BFplus0(BFplus1, BF01)

**Arguments**

BFplus1	Value of $BF_{+1}$ .
BF01	Value of $BF_{01}$ .

**Value**

Numeric scalar,  $BF_{+0}$ .

---

BFplus1 *Bayes factor BF+1: H+ vs H1*

---

**Description**

Bayes factor BF+1: H+ vs H1

**Usage**

BFplus1(y1, y2, n1, n2, a\_1\_d = 1, b\_1\_d = 1, a\_2\_d = 1, b\_2\_d = 1)

**Arguments**

y1                    Number of successes in arm 1 (control).  
y2                    Number of successes in arm 2 (treatment).  
n1                    Sample size in arm 1.  
n2                    Sample size in arm 2.  
a\_1\_d, b\_1\_d        Design-prior shape parameters for  $p_1$ .  
a\_2\_d, b\_2\_d        Design-prior shape parameters for  $p_2$ .

**Value**

Numeric scalar,  $BF_{+1}$  = posterior odds / prior odds for H+ vs H1.

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BFplusMinus *Bayes factor BF+-: H+ vs H-*

---

**Description**

Bayes factor BF+-: H+ vs H-

**Usage**

BFplusMinus(BFplus1, BFminus1)

**Arguments**

BFplus1            Value of  $BF_{+1}$ .  
BFminus1           Value of  $BF_{-1}$ .

**Value**

Numeric scalar,  $BF_{+-}$ .

**Description**

Searches over a grid of total sample sizes  $n$  to find the smallest  $n$  such that Bayesian power, Bayesian type-I error, and probability of compelling evidence under  $H_0$  meet specified design criteria. Optionally, frequentist type-I error and power constraints are also evaluated. Unequal fixed randomisation between the two arms is allowed via `alloc1` and `alloc2`.

**Usage**

```
ntwoarmbinbf01(  
  k = 1/3,  
  k_f = 1/3,  
  power = 0.8,  
  alpha = 0.05,  
  pce_H0 = 0.9,  
  test = c("BF01", "BF+0", "BF-0", "BF+-"),  
  nrange = c(10, 150),  
  n_step = 1,  
  progress = TRUE,  
  compute_freq_t1e = FALSE,  
  p1_grid = seq(0.01, 0.99, 0.02),  
  p2_grid = seq(0.01, 0.99, 0.02),  
  p1_power = NULL,  
  p2_power = NULL,  
  a_0_d = 1,  
  b_0_d = 1,  
  a_0_a = 1,  
  b_0_a = 1,  
  a_1_d = 1,  
  b_1_d = 1,  
  a_2_d = 1,  
  b_2_d = 1,  
  a_1_a = 1,  
  b_1_a = 1,  
  a_2_a = 1,  
  b_2_a = 1,  
  output = c("plot", "numeric"),  
  a_1_d_Hminus = 1,  
  b_1_d_Hminus = 1,  
  a_2_d_Hminus = 1,  
  b_2_d_Hminus = 1,  
  a_1_a_Hminus = 1,  
  b_1_a_Hminus = 1,  
  a_2_a_Hminus = 1,  
)
```

```

    b_2_a_Hminus = 1,
    alloc1 = 0.5,
    alloc2 = 0.5
  )

```

### Arguments

<code>k</code>	Evidence threshold for rejecting the null (inverted BF).
<code>k_f</code>	Evidence threshold for "compelling evidence" in favour of the null.
<code>power</code>	Target Bayesian power.
<code>alpha</code>	Target Bayesian type-I error.
<code>pce_H0</code>	Target probability of compelling evidence under $H_0$ .
<code>test</code>	Character string, one of "BF01", "BF+0", "BF-0", "BF+-".
<code>nrange</code>	Integer vector of length 2 giving the search range for total n.
<code>n_step</code>	Step size for n.
<code>progress</code>	Logical; if TRUE, print progress to the console.
<code>compute_freq_t1e</code>	Logical; if TRUE, compute frequentist type-I error over a grid.
<code>p1_grid, p2_grid</code>	Grids of true proportions for frequentist T1E.
<code>p1_power, p2_power</code>	Optional true proportions for frequentist power.
<code>a_0_d, b_0_d, a_0_a, b_0_a</code>	Shape parameters for design and analysis priors under $H_0$ .
<code>a_1_d, b_1_d, a_2_d, b_2_d</code>	Shape parameters for design priors under $H_1$ or $H_+$ .
<code>a_1_a, b_1_a, a_2_a, b_2_a</code>	Shape parameters for analysis priors under $H_1$ or $H_+$ .
<code>output</code>	"plot" or "numeric".
<code>a_1_d_Hminus, b_1_d_Hminus, a_2_d_Hminus, b_2_d_Hminus</code>	Optional design priors under $H_-$ for directional tests.
<code>a_1_a_Hminus, b_1_a_Hminus, a_2_a_Hminus, b_2_a_Hminus</code>	Shape parameters for analysis priors under $H_-$ .
<code>alloc1, alloc2</code>	Fixed randomisation probabilities for arm 1 and arm 2; must be positive and sum to 1. Defaults are 0.5 and 0.5.

### Value

If `output = "plot"`, returns invisibly a list with recommended sample sizes and a ggplot object printed to the device. If `output = "numeric"`, returns a list with recommended n and summary.

**Examples**

```
# Standard calibration with equal allocation: power 80%, type-I 5%, CE(H0) 80%
ntwoarmbinbf01(power = 0.8, alpha = 0.05, pce_H0 = 0.8, output = "numeric")

# 1:2 allocation (control:treatment) via alloc1 = 1/3, alloc2 = 2/3
ntwoarmbinbf01(power = 0.8, alpha = 0.05, pce_H0 = 0.8,
                alloc1 = 1/3, alloc2 = 2/3, output = "numeric")

# BF+0 directional test with plot
ntwoarmbinbf01(power = 0.8, alpha = 0.05, pce_H0 = 0.9,
                test = "BF+0", output = "plot")
```

---

postProbHminus	<i>Posterior probability <math>P(p_2 \leq p_1 \mid \text{data})</math></i>
----------------	--

---

**Description**

Posterior probability  $P(p_2 \leq p_1 \mid \text{data})$

**Usage**

```
postProbHminus(y1, y2, n1, n2, a_1_d = 1, b_1_d = 1, a_2_d = 1, b_2_d = 1)
```

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_1_d, b_1_d	Design-prior shape parameters for $p_1$ .
a_2_d, b_2_d	Design-prior shape parameters for $p_2$ .

**Value**

Numeric scalar, posterior probability  $P(p_2 \leq p_1 \mid y_1, y_2)$ .

---

postProbHplus	<i>Posterior probability <math>P(p_2 &gt; p_1 \mid \text{data})</math> under independent Beta priors</i>
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---

**Description**

Posterior probability  $P(p_2 > p_1 \mid \text{data})$  under independent Beta priors

**Usage**

```
postProbHplus(y1, y2, n1, n2, a_1_d = 1, b_1_d = 1, a_2_d = 1, b_2_d = 1)
```

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_1_d, b_1_d	Design-prior shape parameters for $p_1$ .
a_2_d, b_2_d	Design-prior shape parameters for $p_2$ .

**Value**

Numeric scalar, posterior probability  $P(p_2 > p_1 \mid y_1, y_2)$ .

---

powertwoarmbinbf01	<i>Bayesian power, type-I error, and PCE(H0) for two-arm binomial Bayes factors</i>
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---

**Description**

Computes Bayesian power, Bayesian type-I error, and the probability of compelling evidence under  $H_0$  (or  $H_-$  for BF+-), for a given sample size and Bayes factor test. Optionally, frequentist type-I error and frequentist power are computed by summing over the rejection region.

**Usage**

```
powertwoarmbinbf01(
  n1,
  n2,
  k = 1/3,
  k_f = 1/3,
  test = c("BF01", "BF+0", "BF-0", "BF+-"),
  a_0_d = 1,
  b_0_d = 1,
```

```

a_0_a = 1,
b_0_a = 1,
a_1_d = 1,
b_1_d = 1,
a_2_d = 1,
b_2_d = 1,
a_1_a = 1,
b_1_a = 1,
a_2_a = 1,
b_2_a = 1,
output = c("numeric", "predDensmatrix", "t1ematrix", "ceH0matrix", "frequentist_t1e"),
a_1_d_Hminus = 1,
b_1_d_Hminus = 1,
a_2_d_Hminus = 1,
b_2_d_Hminus = 1,
compute_freq_t1e = FALSE,
p1_grid = seq(0.01, 0.99, 0.02),
p2_grid = seq(0.01, 0.99, 0.02),
p1_power = NULL,
p2_power = NULL
)

```

### Arguments

n1, n2	Sample sizes in arms 1 and 2.
k	Evidence threshold for rejecting the null (inverted BF).
k_f	Evidence threshold for "compelling evidence" in favour of the null.
test	Character string, one of "BF01", "BF+0", "BF-0", "BF+-".
a_0_d, b_0_d, a_0_a, b_0_a	Shape parameters for design and analysis priors under $H_0$ .
a_1_d, b_1_d, a_2_d, b_2_d	Shape parameters for design priors under $H_1$ or $H_+$ .
a_1_a, b_1_a, a_2_a, b_2_a	Shape parameters for analysis priors under $H_1$ or $H_+$ .
output	One of "numeric", "predDensmatrix", "t1ematrix", "ceH0matrix", "frequentist_t1e".
a_1_d_Hminus, b_1_d_Hminus, a_2_d_Hminus, b_2_d_Hminus	Optional design priors under $H_-$ for directional tests.
compute_freq_t1e	Logical; if TRUE, compute frequentist type-I error over a grid.
p1_grid, p2_grid	Grids of true proportions for frequentist T1E.
p1_power, p2_power	Optional true proportions for frequentist power.

### Value

Depending on output, either a named numeric vector with components Power, Type1\_Error, CE\_H0 (and optionally frequentist metrics) or matrices of predictive densities.

**Examples**

```
# Basic Bayesian power for BF01 test
powertwoarmbinbf01(n1 = 30, n2 = 30, k = 1/3, test = "BF01")

# Directional test BF+0 with frequentist type-I error
powertwoarmbinbf01(n1 = 40, n2 = 40, k = 1/3, k_f = 3,
  test = "BF+0", compute_freq_t1e = TRUE)

# Predictive density matrices (advanced)
powertwoarmbinbf01(n1 = 25, n2 = 25, output = "predDensmatrix")
```

---

predictiveDensityH0    *Predictive density under H0:  $p1 = p2 = p$*

---

**Description**

Beta-binomial predictive density for data (y1,y2) under H0.

**Usage**

```
predictiveDensityH0(y1, y2, n1, n2, a_0_d = 1, b_0_d = 1)
```

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_0_d, b_0_d	Design-prior parameters for common p under H0.

**Value**

Numeric scalar, predictive density.

---

predictiveDensityH1    *Predictive density under H1:  $p1 \neq p2$*

---

**Description**

Product of two independent Beta-binomial predictive densities.

**Usage**

```
predictiveDensityH1(y1, y2, n1, n2, a_1_d = 1, b_1_d = 1, a_2_d = 1, b_2_d = 1)
```

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_1_d, b_1_d	Design-prior parameters for p1.
a_2_d, b_2_d	Design-prior parameters for p2.

**Value**

Numeric scalar, predictive density.

---

predictiveDensityHminus\_trunc

*Predictive density under H-:  $p2 \leq p1$  (truncated prior)*

---

**Description**

Predictive density under H-:  $p2 \leq p1$  (truncated prior)

**Usage**

```
predictiveDensityHminus_trunc(
  y1,
  y2,
  n1,
  n2,
  a_1_d = 1,
  b_1_d = 1,
  a_2_d = 1,
  b_2_d = 1
)
```

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_1_d, b_1_d	Design-prior parameters for p1.
a_2_d, b_2_d	Design-prior parameters for p2.

**Value**

Numeric scalar, predictive density under H-.

---

predictiveDensityHplus\_trunc

*Predictive density under H+:  $p_2 > p_1$  (truncated prior)*

---

### Description

Predictive density under H+:  $p_2 > p_1$  (truncated prior)

### Usage

```
predictiveDensityHplus_trunc(
  y1,
  y2,
  n1,
  n2,
  a_1_d = 1,
  b_1_d = 1,
  a_2_d = 1,
  b_2_d = 1
)
```

### Arguments

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_1_d, b_1_d	Design-prior parameters for $p_1$ .
a_2_d, b_2_d	Design-prior parameters for $p_2$ .

### Value

Numeric scalar, predictive density under H+.

---

priorProbHminus

*Prior probability  $P(p_2 \leq p_1)$  under independent Beta priors*

---

### Description

Prior probability  $P(p_2 \leq p_1)$  under independent Beta priors

### Usage

```
priorProbHminus(a_1_d, b_1_d, a_2_d, b_2_d)
```

**Arguments**

- a\_1\_d, b\_1\_d      Shape parameters of the Beta prior for  $p_1$ .  
 a\_2\_d, b\_2\_d      Shape parameters of the Beta prior for  $p_2$ .

**Value**

Numeric scalar, prior probability  $P(p_2 \leq p_1)$ .

---

priorProbHplus	<i>Prior probability <math>P(p_2 &gt; p_1)</math> under independent Beta priors</i>
----------------	---

---

**Description**

Prior probability  $P(p_2 > p_1)$  under independent Beta priors

**Usage**

```
priorProbHplus(a_1_d, b_1_d, a_2_d, b_2_d)
```

**Arguments**

- a\_1\_d, b\_1\_d      Shape parameters of the Beta prior for  $p_1$ .  
 a\_2\_d, b\_2\_d      Shape parameters of the Beta prior for  $p_2$ .

**Value**

Numeric scalar, prior probability  $P(p_2 > p_1)$ .

---

twoarmbinbf01	<i>Two-arm binomial Bayes factor <math>BF_{01}</math></i>
---------------	---

---

**Description**

Computes the Bayes factor  $BF_{01}$  comparing the point-null  $H_0 : p_1 = p_2$  to the alternative  $H_1 : p_1 \neq p_2$  in a two-arm binomial setting with Beta priors.

**Usage**

```
twoarmbinbf01(  
  y1,  
  y2,  
  n1,  
  n2,  
  a_0_a = 1,  
  b_0_a = 1,  
  a_1_a = 1,  
  b_1_a = 1,  
  a_2_a = 1,  
  b_2_a = 1  
)
```

**Arguments**

y1	Number of successes in arm 1 (control).
y2	Number of successes in arm 2 (treatment).
n1	Sample size in arm 1.
n2	Sample size in arm 2.
a_0_a, b_0_a	Shape parameters of the Beta prior for the common- $p$ under the null model.
a_1_a, b_1_a	Shape parameters of the Beta prior for $p_1$ under the alternative.
a_2_a, b_2_a	Shape parameters of the Beta prior for $p_2$ under the alternative.

**Value**

Numeric scalar, the Bayes factor  $BF_{01}$ .

**Examples**

```
twoarmbinbf01(10, 20, 30, 30)
```

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